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60 GHz High Integrated Transceiver for Broad Band Short Distance Communication

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ABSTRACT

The V-band of 60 GHz small mobile transceiver with integrated IF modem for millimeter-wave over fiber communication application is described in this paper. The transceiver is integrated with 60 GHz transmitter, receiver, wave guide band pass filter, 2x2 circular array antenna and IF modem in one module of small size 130 mm x 80 mm x 33 mm. The transceiver transmits the data rate of 155.52 Mbps and measured BER is better than 10E-7,

INTRODUCTION

Millimeter-wave over fiber (MOF) communication system in V-band is considered for the design of high data rate communication network in short distance application. The MOF has the advantage of long distance connection without high transmission loss through the fiber compare with the 60 GHz air link connection. This benefit can be used in the last one mile wireless connection or hot spot communication access. In general, this system consist of control station (CS), access point (AP), and mobile terminal (MT). Especially MT should have mobility and compact size for end user application. But the previous developed 60 GHz mobile transceiver has the bulk size without IF modem [1][2]. In this paper we describe 60 GHz small mobile transceiver (SMT) which is realized using the technologies of the broadband gap-coupled patch type microstrip line to rectangular waveguide transition, cavity type circular array antenna, integrated waveguide band pass filter, monolithic microwave integrated circuits (MMICs), simple configuration of frequency synthesizer, and integrated IF modem. The implemented transceiver is very compact size, high performance and this 60 GHz SMT can be installed in the wireless LAN or road-to-vehicle communication conveniently.

60 GHz TRANSCEIVER CONFIGURATION

The developed transceiver consists of one transmitter, one receiver, IF modem and this has the configuration of frequency division duplex (FDD) which is shown in Fig. 1. The transmitter frequency band is 61-62 GHz and the receiver use the frequency of 59-60 GHz. The isolation between transmitter and receiver is obtained by using the separate antenna and waveguide band pass filter with high suppression at out of pass band. In both transmitter and receiver the 2x2 circular waveguide array antenna is used. For transition between waveguide band pass filter and microstrip-line circuit, a wideband gap coupled patch type transition is used[3]. The antenna gain is 14 dBi at center frequency and 3 dB beamwidth is 30^o in horizontal and vertical plan. The waveguide band pass filter has an insertion loss of 1 dB with 3 dB bandwidth of 1 GHz, and the rejection is 60 dB at 2 GHz higher separation from the center frequency of 59.5 GHz in the receiver and the rejection of 40 dB at 2 GHz lower separation from the center frequency of 61.5 GHz in the transmitter, respectively.

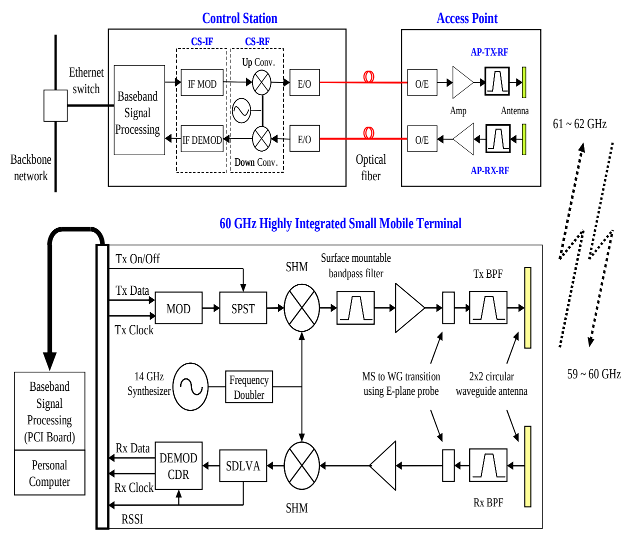


Fig. 1 Block diagram of 60 GHz mobile transceiver.

In the up- and down converter, the sub-harmonic image rejection mixers with 90^o hybrid coupler are used. This kind of configuration simplify the transceiver due to less complexity of LO synthesizer. For the LO frequency, 14 GHz is phased locked in PLL and this frequency is amplified, multiplied to 28 GHz. The phase noise of LO frequency is -96.7 dBc/Hz @ 100 KHz offset at 14 GHz and at 28 GHz the phase noise is inferred -90.64 dBc/Hz @ 100 KHz offset from the measured result. The transmitter power is 10 dBm at the output of the waveguide band pass filter, and the noise figure of receiver is 6.5 dB.

The modulator and demodulator of 155.52 Mbps are integrated in the same module. The modulator section consist of a double balanced mixer, a 5.5 GHz synthesizer, and a pin driver circuit. The DPSK signal is generated through the modulator using the Tx data, Tx clock, and Tx control with LVDS logic level transmitted from the base band signal processing unit in PCI card. The modulated signal of 5.5 GHz is entered into the sub-harmonic image rejection mixer. The Tx control signal controls the SPST switch according to the reservation-based slotted idle signal multiple access (RS-ISMA).

The demodulator section consist of a band pass filter, a successive detection log video amplifier (SDLVA), a DPSK demodulator, and 155.52 Mbps clock and data recovery (CDR) circuits. The received 60 GHz RF signal is converted into the 3.5 GHz DPSK signal. This signal entered into SDLVA. It provide two signals; the DPSK signal which has +12 dBm with limited power constantly irrespective of the strength of received signal power, and the received signal strength indicator (RSSI) according to the received signal power. It has the 70 dB dynamic range and tangential signal sensitivity (TSS) of -70 dBm.

Table 1 Specification of transceiver

Transmitter	
RF output frequency	61 ~ 62 GHz
RF output power	+10 dBm
RF output 1 dB	+16 dBm
IF frequency	5 ~ 6 GHz
Antenna gain	14 dBi
Antenna 3 dB beamwidth	$30^o(EL)\times 30^o(AZ)$
Noise bandwidth	234 MHz
Receiver	
RF input frequency	59 ~ 60 GHz
Noise figure	6.5 dB
IF frequency	3 ~ 4 GHz
Antenna gain	14 dBi
Antenna 3 dB beamwidth	$30^o(EL)\times 30^o(AZ)$
Noise bandwidth	234 MHz
Common	
Antenna polarization	RHCP
Duplex /Access protocol	FDD / RS-ISMA [3]
Modulation	DPSK
Data rate	155.52 Mbps
Baseband interface	LVDS

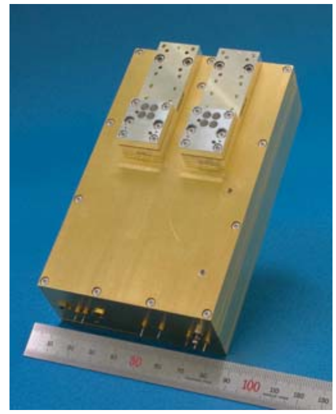
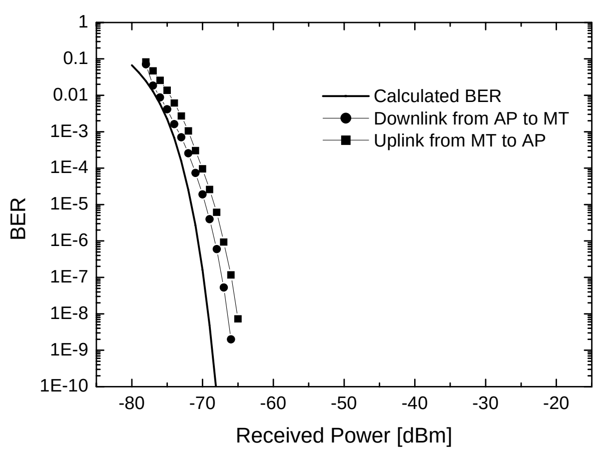


Fig.2 Photo of 60 GHz Mobile Transceiver.

The DPSK demodulator consists of a delay line, two hybrid couplers, and two detector diodes. The data and clock is regenerated from the detected 155.52 Mbps signal using CDR circuit. A RSSI signal is used to reset the CDR. These signals are transmitted to a base band signal processing unit via LVDS cable. Table 1 shows the detail system specification, and Fig. 2 shows the implemented 60 GHz small mobile terminal.

PERFORMANCE MEASUREMENT

Performance of developed mobile terminal is measured in bit error rate (BER). Experiment is performed in uplink case from SMT to AP and CS, and in downlink from CS and AP to SMT. Fig.3 show the measured results of BER and PER, respectively. The target BER in the design of system is less than 1E-7 to transmit the MPEG-2-based video data. The received power is -67.5 dBm in the uplink and -65 dBm in the downlink which satisfy the requirement of BER 1E-7. The different BER characteristics between uplink and downlink are caused by the system impairment.



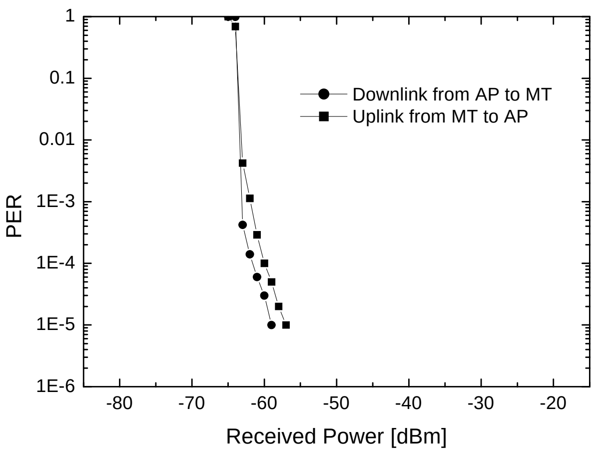


Fig. 3 Measured BER and PER of up-/down link

CONCLUSION

We have developed a 60 GHz small mobile terminal for the wireless LAN or road-to-vehicle communication system. For the circuits in mobile terminal, the broadband gap-coupled patch type microstrip line to rectangular waveguide transition, cavity type circular array antenna, the integrated waveguide band pass filter, monolithic microwave integrated circuits (MMICs), simple configuration of frequency synthesizer are implemented. Through the BER experiments, the performance of developed transceiver is confirmed. This small size terminal can be used in a various high data rate (higher than 155.52 Mbps) communication application.

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